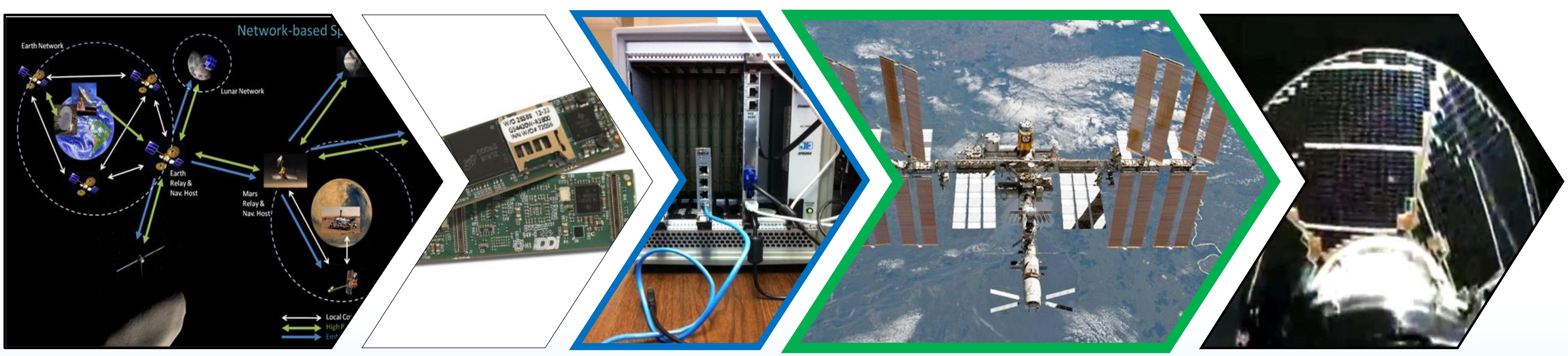
Evan Anzalone, PhD, NASA/MSFC
evan.j.anzalone@nasa.gov

Multi-spacecraft Autonomous Positioning System

Low Earth Orbit Demo Development and Hardware-in-the-Loop Simulation

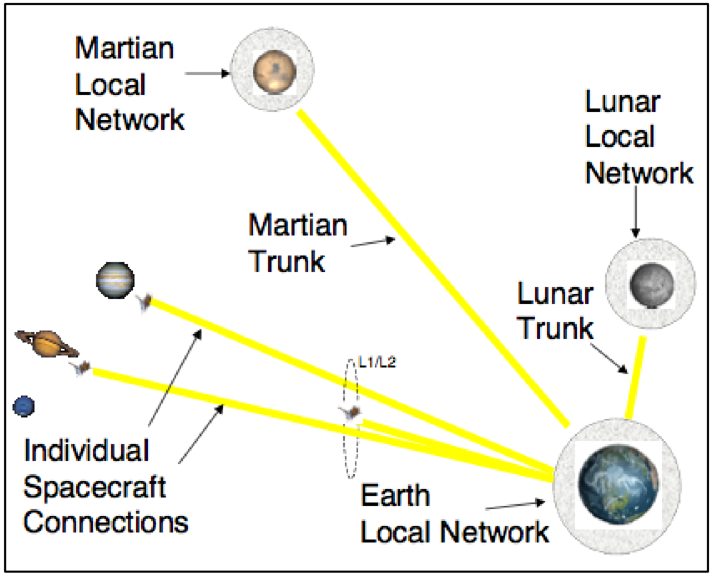


August 10, 2015, Logan, UT

AIAA/USU SmallSat Conference

Technical Background

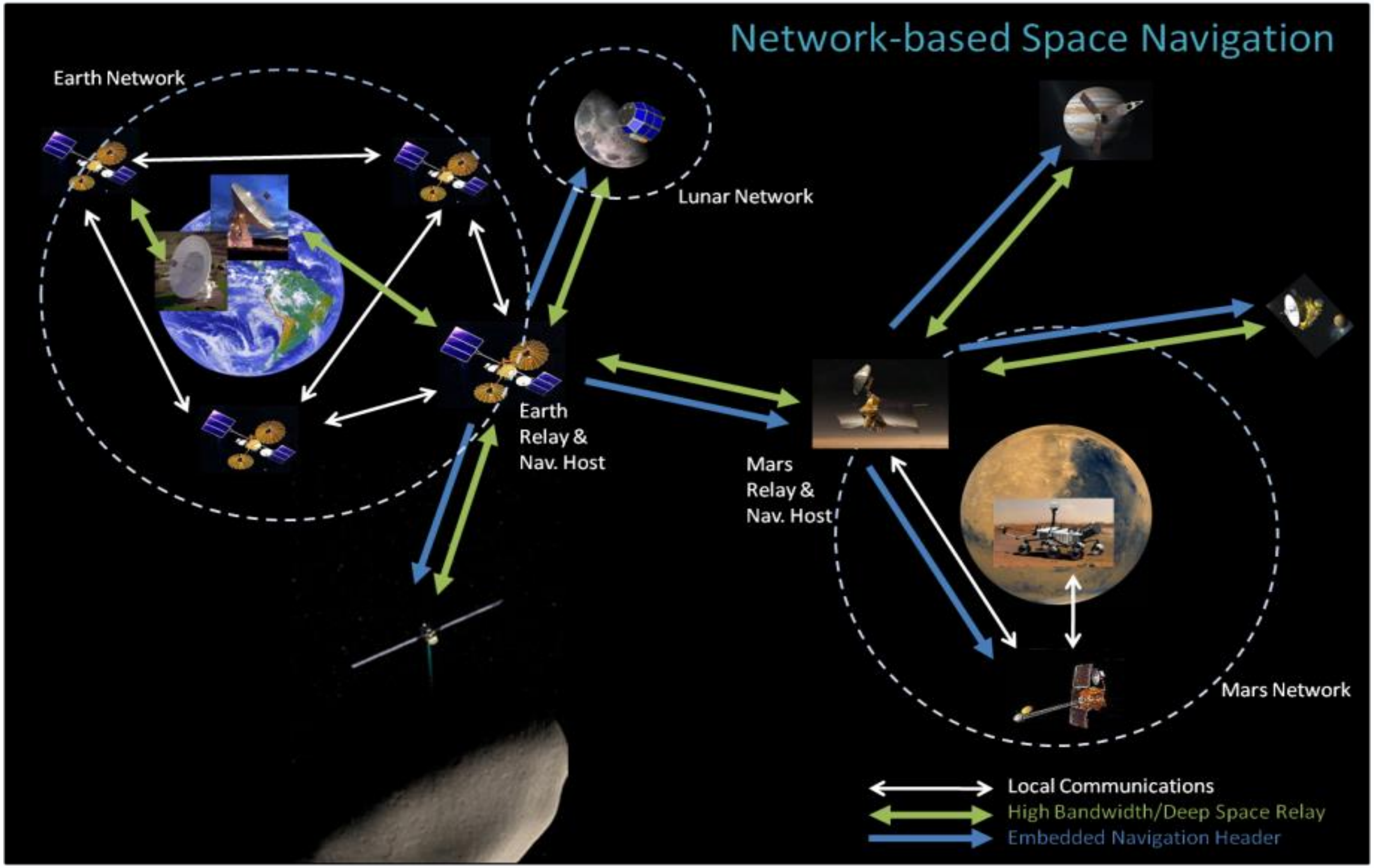
- Current navigation technology
  - Radiometric tracking
  - Optical navigation
- Ongoing research
  - X-ray navigation
  - Pulsar/Gamma ray navigation
  - High accuracy onboard timing systems
  - Inter-asset radiometric tracking
  - Autonomous optical navigation
- Inspired by use of data relays in inter-spacecraft communications
- Embed navigation headers into communication packets
- Utilization of onboard state propagation models and state estimation algorithms to track current position



NASA SCAWG

Embedding navigation headers into communication packets works with existing infrastructure, tailored to match onboard capability, and provides expanding navigation network.

MAPS Architecture Concept



MAPS provides revolutionary capability for an expanding interplanetary navigation network, ready now for hardware testing.

MAPS Development Summary and Achievements

- FY12 – Concept formulation, development, and simulation
- FY13 – Component selection and sourcing
- FY14 – Initial hardware in the loop (HIL) development and demonstration mission definition
- FY15 – HIL integration and analysis for LEO demonstration mission
  - Full spacecraft integration into SPRITE HIL simulation
  - Interface with flight-like radios
  - Enhance timing measurement and accuracy of HIL simulation
  - Expand mission analysis to LEO Demonstration Mission

MAPS Architecture has a strong analytical foundation and quickly moving towards implementation and demonstration.

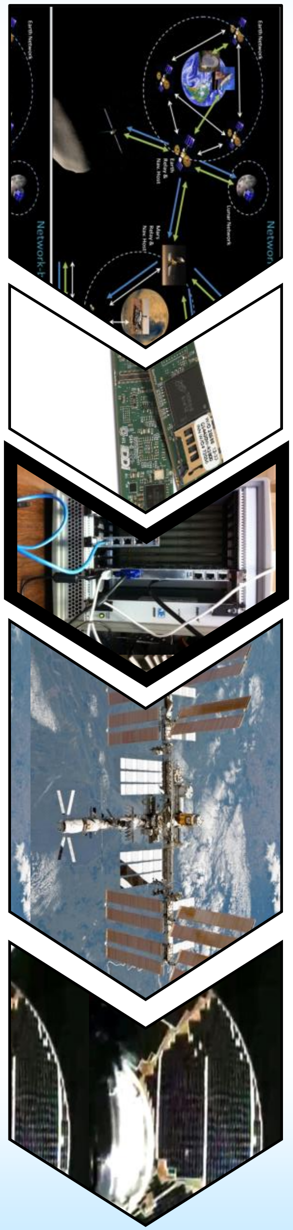
FY11-12

FY13

FY14-15

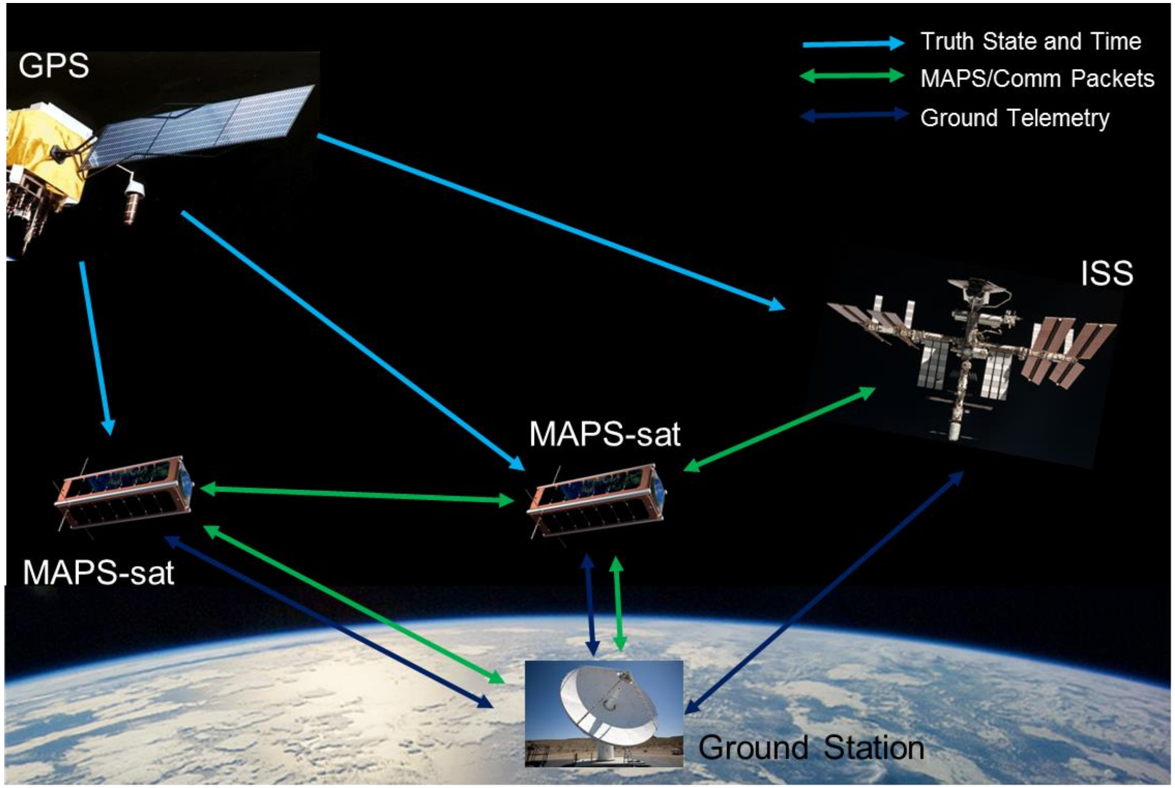
FY16-17

FY 18+



Demonstration Mission Concept of Operations

- Design and build CubeSat to demonstrate MAPS architecture in LEO
  - Use GPS as truth reference position and time system
  - Utilize communication links between CubeSats (2) and/or ISS/SCaN payload

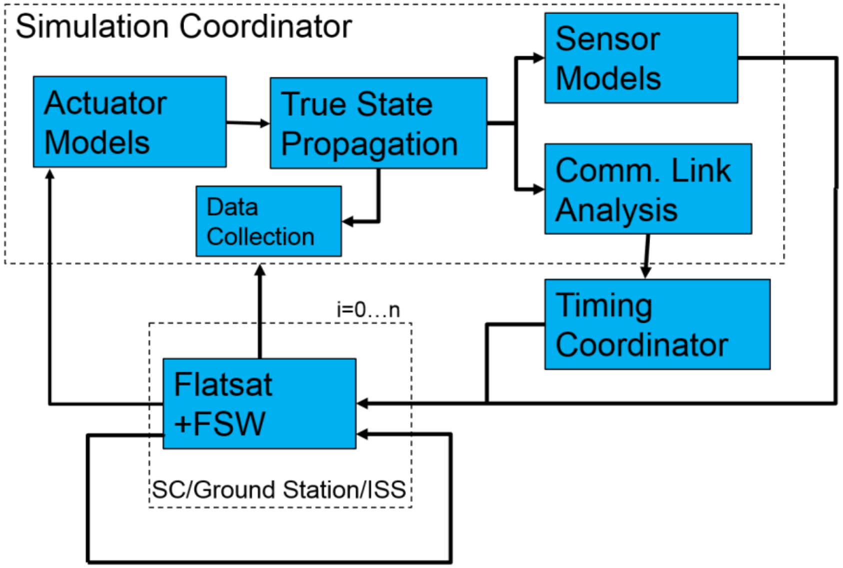


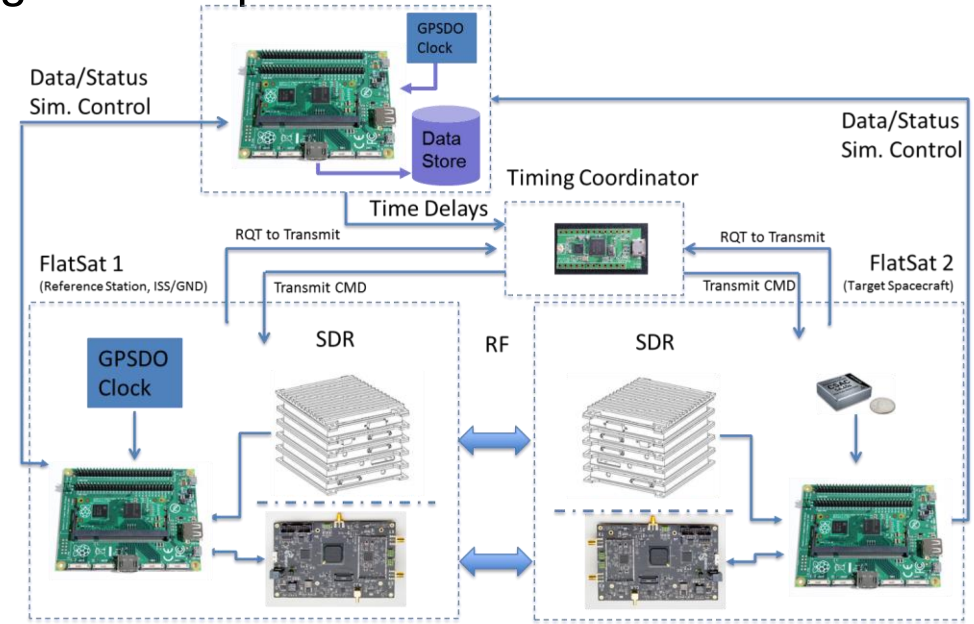
- Maximize use of COTS components to minimize development time and effort

LEO demonstration provides simple and fast path-to-flight for algorithm with a straightforward, low-risk, low-cost vehicle design

HIL Architecture Design and Implementation

- LibSprite library enables onboard real-time processing
- Simulation Coordinator controls inputs/outputs and data exchanges
- Hardware emulators provide sensor inputs and interface
- FlatSats implement Flight Software and sensor drivers to evaluate navigation capabilities through algorithm implementation

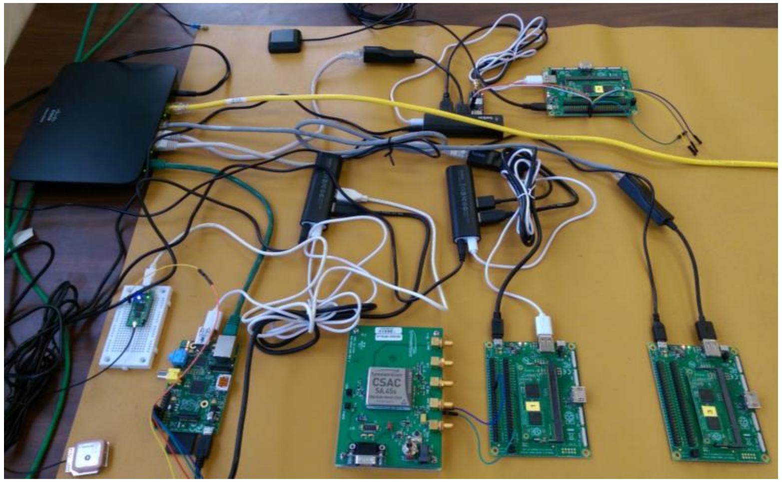


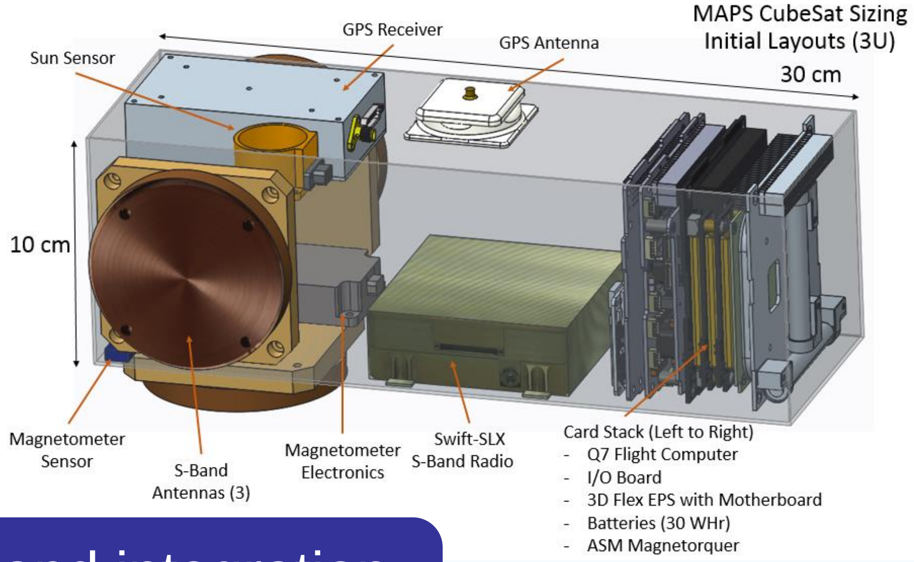


Common software and hardware framework across agents to allow for modular mission definition, sensor and actuator emulation, and expandable mission scenarios.

Continued Development Path

- Flight Development
  - Pursuing flight opportunities for initial demonstration mission
  - Designing and Integrating EDU-grade components in CubeSat design
  - Developing relationships to partner on hardware development
- Long-term Architecture Development
  - Utilizing simulation framework for deep space navigation technology performance assessment
  - Developing portable MAPS FSW library
  - Development Deep Space Demonstration Mission
  - Expand into interplanetary network of assets





Developing flight implementation and integration via Software and Hardware Development Efforts

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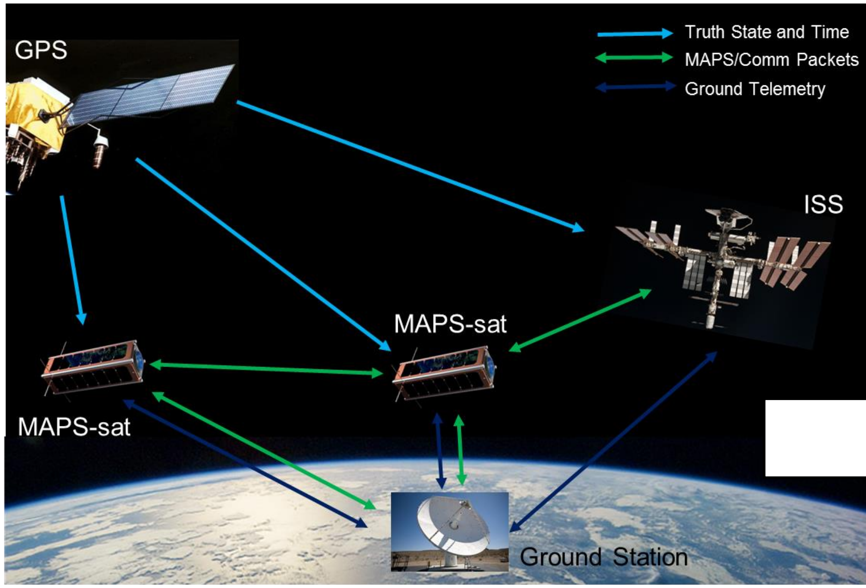

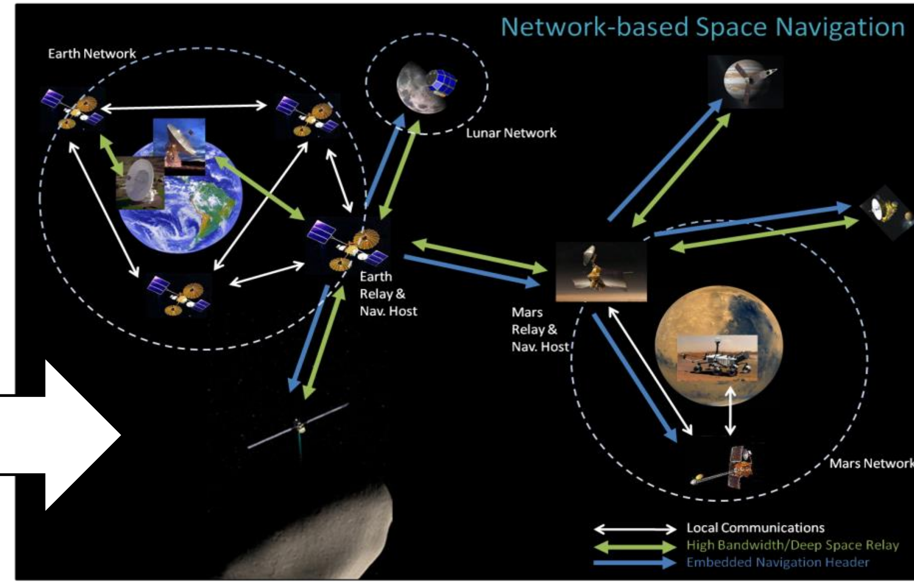

Using Hardware-in-the-Loop Simulation to Prepare for LEO Demonstration and Eventual Solar System-Wide Deployment of a Communication Network-Embedded Navigation Capability

Thank you!